May 29, 2000

Director Charles Shank
Lawrence Berkeley National Laboratory
One Cyclotron Road
Berkeley, CA 94720

Dear Director Shank:

We, the undersigned members of the Environmental Sampling Task Force,appreciate the California Regional Water Quality Control Board's concerns regarding Lawrence Berkeey national Laboratory's radiological impactrs on water quality on our community. We agree with RWQCB that investigating tritium in groundwater is essential to a complete evaluation of all exposure pathways.

We request that LBNL incorporate the Regional Water Quality Control Boards requirements in the sampling plan and that a representative from that board now be seated on the task force.

Sincerely,

[signed by the following Task Force members]:

Laurie Bright, COPE
Carroll B. Williams, Panoramic Hill Association
Pamela Sihvola, CMTW

California Regional Water Quality Control Board
San FranciscoBayRegion
Internet Address: http://www.swrcb.ca.gov
1515 Clay Street, Suite 1400, Oakland, California 94612
Phone (510) 622-2300 Fax (510) 622-2458

Date: May 1, 2000
File No. 2199.9026 (MBR)

Mr. Ron Pauer
Mr Iraj Javandel
Environmental Restoration Program
Lawrence Berkeley National Laboratory
One Cyclotron Road
Mail Stop 90-1116
Berkeley, California 94720

SUBJECT: Draft Tritium Sampling and Analysis Plan for
LBNL Environmental Protection Group, May 1999

Dear Dr. Javandel:

The San Francisco Bay Regional Water Quality Control Board staff (RWQCB) has reviewed the above referenced document and is providing the attached comments. LBNL is requested to respond within 60 days of receipt of these comments in a response to comments letter. Once revisions are agreed upon, they should be incorporated into the draft final document.

If you have any questions or comments, please contact me at (510) 622-2411.

Sincerely,
Michael Bessette Rochette

Attachment: RWQCB Comments

cc: Phillip Armstrong, USEPA
Shelly Rosenblum, USEPA
Edgar Bailey, DHS
Sal Ciriello, DTSC
Tony Natera, DTSC
Nabil Al-Hadithy, City of Berkeley
Hemet Patel, DOE
Pamela Shiva, Committee to Minimize Toxic Waste

San Francisco Bay Regional Water Quality Control Board | DOE Section
Prepared by: Michael Rochette | Phone No.: (510) 622-2411
Date: May 1, 2000 | File No.: 2199.9026 (MBR)
Subject: Draft Tritium Sampling and Analysis Plan

General Comments:

1)The RWQCB has concerns regarding radiological impacts to water quality at LBNL. Tritium concentrations in groundwater in the area near the National Tritium Labeling Facility (NTLF) are elevated above background concentrations and, in a one groundwater monitoring well, exceed United States Environmental Protection Agency's (EPA's) tritium Maximum Contaminant Level (MCL) for drinking water. The source of the tritium in groundwater is identified in the Draft Final RCRA Facility Investigation Report, Feb. 1997, as the NTLF stack, an atmospheric emission permitted by EPA under National Emission Standards for Hazardous Air Pollutants (NESHAPs). The RWQCB is specifically concerned that tritium impacts to groundwater be included as part of EPA's hazard ranking system evaluation of risks to human health and the environment. For quality assurance and technically defensible results, a complete evaluation of all tritium exposure pathways from known and potential sources through all media including groundwater to existing and potential receptors must be performed using existing and the new data to be collected as part of this tritium sampling plan.

2) Please note that the San Francisco Bay Basin Water Quality Control Plan (Basin Plan) identifies existing beneficial uses of the East Bay Plain groundwater underlying LBNL as: Municipal and Domestic water supply; Industrial Process water supply; Industrial Service water supply; Agricultural water supply; and Freshwater replenishment supply. A risk assessment without an evaluation all these existing and/or potential beneficial uses of groundwater and the associated exposure pathways is incomplete.

3) While the tritium emissions from the stack met EPA's NESHAPs requirements, the emissions are identified as the tritium source of existing groundwater contamination and are potentially a continuing source further impacting groundwater. RWQCB recommends LBNL focus their efforts on pollution prevention and ongoing source reduction. By proactively addressing the tritium, RWQCB hopes to avoid a situation where concentrations increase and trigger a corrective measure study which will be of limited value due to the lack of remedial technologies presently available to effectively remediate tritium in groundwater. What options will LBNL or EPA evaluate in order to address this situation? Will LBNL recommend EPA reevaluate the standards to be protective of groundwater quality and provide LBNL with new emission standards, or will LBNL evaluate a reduction of the total mass of the tritium emission even without such a regulatory requirement?

Specific Comments:

1) Page 4, Sec. 1.1, Para. 2: Text should be revised to reflect that tritium concentrations in groundwater samples collected near the NTLF exceed background concentrations and samples collected in Monitoring Well, MW 75-97-5, south of the NTLF, have continually exceeded the drinking water tritium MCL of 20,000 pico-Curries per liter (piC/l) and may require corrective action. The following table presents the highest tritium concentrations per recent groundwater sampling events from Monitoring Well, MW 75-97-5:

1st Qtr. 99	2nd Qtr. 99	3rd Qtr. 99	4th Qtr. 99	1st Qtr. 00
28,200 piC/l;	31,503 piC/l	24,991 piC/l	26,211 piC/l	27,047 piC/l

2) Page 4, Sec. 1.1, Para. 3: Sampling and Analysis Plan investigation objectives should also include an evaluation of impacted groundwater to evaluate potential risk to human health and the environment. An investigation of tritium contained in soil, surface water, sediment, ambient air but not groundwater will leave a significant exposure pathway unaddressed for any future risk assessments. Without a complete evaluation of all exposure pathways from the known and potential sources of tritium through air, soil, soil gas, and groundwater to existing and potential receptors as identified in the Basin Plan beneficial uses, the risk assessment model will not meet the QAQPjP objectives.

3) Figure 2.1: Revise chart to reflect RWQCB involvement and any other agency changes.

4) Page 9, Sec. 2.1.2: Revise text to include: RWQCB may provide recommendations if water quality objectives are impaired.

5) Page 11, Sec. 2.2, Para. 2: How do recent soil gas and groundwater tritium data fit the LBNL human health risk assessment (HHRA) exposure concentration model utilized in 1997? What are the Ecological Risk Assessment results with respect to tritium? Were the following issues addressed in the 1997 HHRA?

• Identification of all existing and potential groundwater beneficial uses
• Land or groundwater use restrictions;
• Identification of horizontal and vertical preferential pathways;
• Evaluation of potential tritium sources such as sanitary sewer or storm water pipelines;
• Characterization of risk associated other radionuclides other than tritium;
• Determination of background and ambient conditions.

6) Page 16, Sec. 2.3: Stating no decision rules will be associated with a total tritium concentration appears to be a decision rule in and of itself, by limiting what analytical data that will be used in the decision process. This decision should be detailed in Section 2.4.

7) Page 17, Sec. 2.4: Provide text describing the rational for selecting specific analytical methods as part of a decision rule. Section 2.3 references this section and the text should discuss what is actually being sampled and why, weighing advantages and disadvantages, i.e., total tritium, tritiated water vapor, tissue-free water tritium, or organically bound tritium.

(Committee to Minimee Toxic Waste)

To: Members the LBNL's Tritium Sampling Task Force
From: Pamela Sihvola, Co-chair CMTW (Task Force alternate representative)

6/1/00

Dear Members:

I have attached portions of a pilot sampling study titled *Tritium in Vegetation at LBNL* for your review. I believe that this vegetation sampling done around the tritium stack, within a 300 meter radius, is of great value to our group. It provides an clear understanding of the transport of tritium within the eastern portion of the Laboratory. The pilot study was conducted under the direction of Ron Pauer of LBNL's EH&S Division and the sample analysis were performed by Thermo NUtech.

I would propose that the Task force take a serious look at this tritium sampling project for our next meeting. Further, I hope the group would invite the author of the study, Dr. Menchaca to come and give a presentation to the Task force and also that LBNL will provide the full report for our review.

Additionally, this study should be provided to the city of Berkeley's contractor, Bernd Franke of IFEU and LBNL's contractor, Owen Hoffman of Senes for their peer review.

Finally, the *Tritium in Vegetation at LBNL* study, is extremely relevant to the both the NTLF site and tritium sampling. It will allow the group to "get a handle" on this very complicated issue.

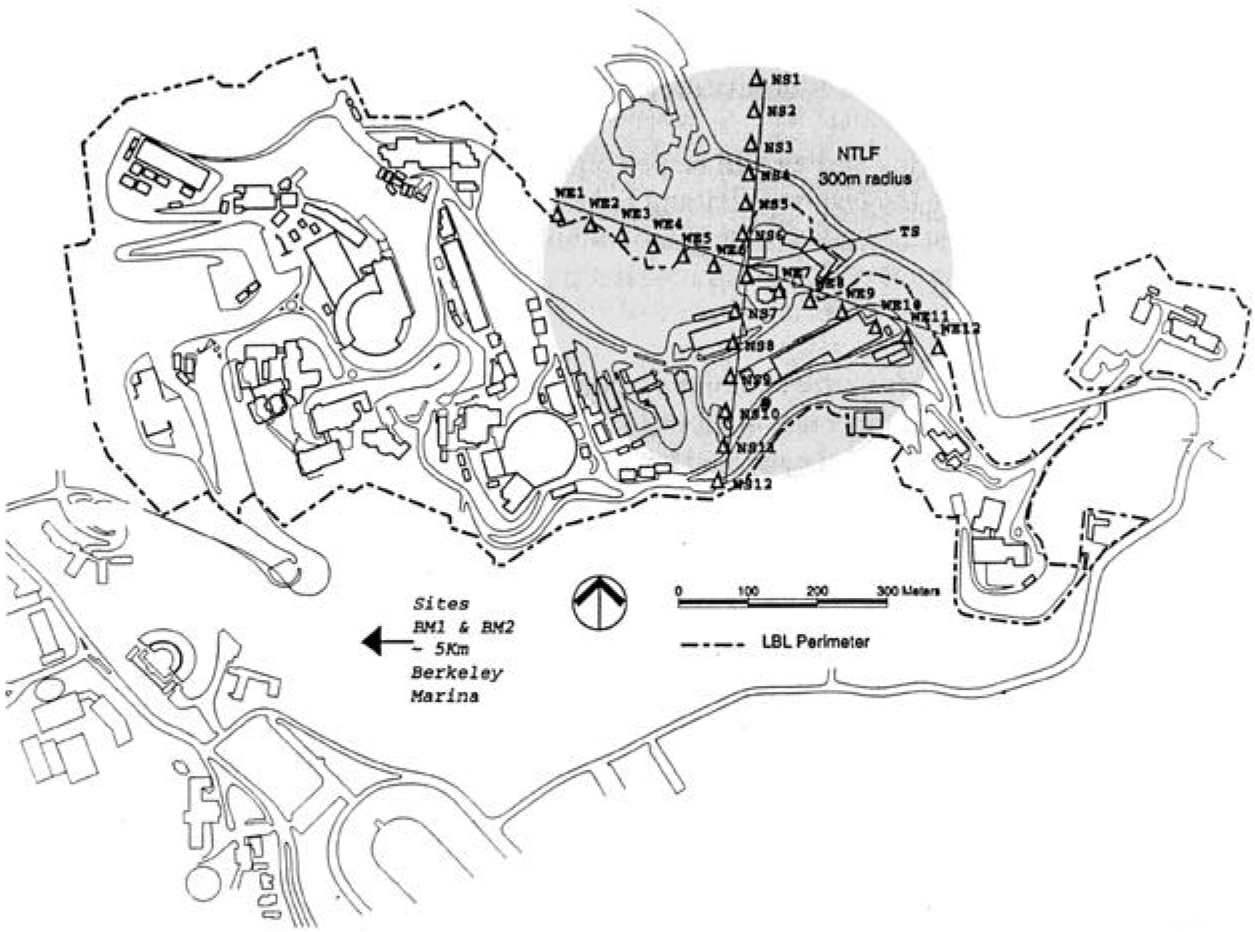


Figure 9-1. Areas of Investigation and sampling points for Tritium Activity

Tritium in Vegetation

An investigation was conducted in 1996 to determine tritium activities in vegetation. Two components were measured, the unbound fraction recovered during distillation and the organically bound tritium remaining in the foliage after drying. Plants predominantly uptake tritium like any of the other isotopes of hydrogen, through root water uptake. The organically bound tritium is incorporated into sugars, carbohydrates, and other hydrogen bearing molecules that constitute the plant biomass. Although the organically bound and unbound hydrogens exchange, it is generally recognized that unbound tritium in foliage reflects the current subsurface water uptake through the xylem stream, while the organically-bound fraction generally reflect conditions at the time of formation of the leaf.

Tritium contamination in soils and shallow groundwaters at Berkeley Lab is essentially confined to the eastern portion of the Laboratory, adjacent to the Tritium Stack (TS) of the NTLF. The investigation focused on an area defined by a 300 meter radius around the NTLF stack; sampling locations are shown in Figure 1. The labels WE and NS stand for transects West to East and North to South, respectively. Samples of tree foliage (~250 grams) were collected in September, 1996, at the end of the dry season. The foliage samples were collected from several branches of a single tree at each location. The samples were taken to the Radiation and Analytical Measurements Laboratory at Berkeley Lab within one day of the time of collection.

At the RAML, a split from each sample (~100g) was dried at 100°C for three days and submitted to a commercial laboratory for analysis of organically-bound tritium using a flame combustion method. The remaining four samples were cut into small pieces (~05 cm^2) and stored under refrigeration in 500 ml sealed glass jars in for a maximum of 5 days prior to analysis. Sample aliquots (~40 g) were transferred to 250 ml Pyrex boiling flasks and water was extracted by azeotropic distillation for one hour using ~100 ml of cyclohexane. The extraction method used is described in LBNL Chemical Analysis Procedures, Method No. 0464804-D-92-412.223m. Aliquots (10 ml) of the water extend from the foliage samples were quenched with 10 ml of Ultima Gold XR, left to decay in darkness for 4 hours, and counted for tritium with correction for ^{14}C in a LSC 2500:TR/RB Packard liquid scintillation counter, using Protocol 16 (Dual DPM data mode). The counting time was 100 minutes. Deionized water was used as a blank and the spike was NIST traceable CH3-E, 1596 DPM from EPA.

Average unbound tritium activity results for the sampled trees are shown in Table 9-1. The table also shows the number of samples analyzed and the highest activity found for any individual tree. The highest dispersion from the mean was found in tree TS, located approximately 2 meters from the NTLF stack. With the exception of trees WE3 and WE11, all trees sampled were adult pines or eucalyptus growing in areas where no irrigation is applied. Tree WE3 is an elm growing in the back lawn of the Lawrence Hall of Science where it is irrigated by a sprinkler located approximately one meter from the tree. Tree WE11 is an irrigated redwood growing within a planter adjacent to Building 72.

Tables 9-2 and 9-3 show the average unbound and organically bound tritium activities, respectively, in relation to distance from the NTLF stack. Although the data are incomplete, within 150 meters to the west of the NTLF stack, tritium is concentrated in the solid plant material by a factor of approximately 20 to 30 compared to the unbound tritium.

Although tritium activities in vegetation decrease with distance from the NTLF stack, the decline is not uniform in all directions. Figure 9-2 shows the tritium activity gradients along the four directional transects away from the NILF stack. The highest tritium activities and the steepest declines are found to the West of the NTLF stack, where activities drop to ~ 50% (4,346 pCi/L) of the activity values found at the stack (77,355 pCi/L) within 200 meters. In all other directions, activities are lower and drop to ~10 % of the highest value within the first 50 meters. By 300 meters from the stack, activities drop to 0.25 to 1.8 % of the values found at the stack, with the highest values to the North.

Table 9-1. 1996 Average Tritium Activity Values in Water Extracted from Plant Foliage Samples

Station	Number of Samples	Average (pCi/L)	Max (pCi/L)	Station	Number of Samples	Average (pCi/L)	Max (pCi/L)
WE1	3	571	671	NS1	3	1400	1421
WE2	3	775	1006	NS2	3	1723	2148
WE3	3	4346	4866	NS3	3	2761	2882
WE4	4	11587	12029	NS4	3	2773	2843
WE5	4	13842	14766	NS5	3	3556	3656
WE6	4	17667	18054	NS6	3	8104	8430
WE7	6	5219	7949	NS7	2	6875	6911
WE8	3	1277	1348	NS8	3	303	305
WE9	3	1296	1365	NS9	2	1022	1059
WE10	3	315	370	NS10	4	673	835
WE11	3	239	285	NS11	2	503	534
WE12	3	323	507	NS12	2	201	221
TS	4	77351	128185				

Leaf moisture reflect current levels of atmospheric tritium (when atmospheric humidity is high) and the tritium concentrations in the waters currently being uptaken by the root and transported to the leaf (In the leaf, evapotranspiration takes place and mass dependent isotopic fractionation occurs). The lighter isotopes of hydrogen escape into the vapor phase more readily than the heavier isotopes, causing a slight enrichment of tritium (the heaviest of the hydrogen isotopes) in the leaf fluids. For large old trees, the bulk of the trunk consists of biomass produced by the tree in prior years (necromass) and each growing ring reflects primarily the tritium concentrations in the subsurface water that the tree root was uptaking at the time.

In order to increase the confidence, enhance the utility, and broaden the applicability of tritium measurements on Berkeley Lab. biota, it is recommended that the following steps be taken:

1. To determine the actual tritium concentrations of plant materials, it is necessary to analyze both the unbound tritium in leaf water and the bound tritium in the plant biomass. This will require the purchase and installation of an oxidizer to convert the hydrogen in the plant biomass to water, this can be done subsequent to distillation of the unbound water.

2. Because the small amounts of tritium in most areas of Berkeley Lab could be used as tracers for surface and subsurface water transport, counting times should be lengthened and appropriate reference blanks should be used to allow discrimination of lower activity levels in the samples.

3. The limits of tritium dispersion on and near the Berkeley Lab should be determined, especially to the North of the NTLF and to the south of Buildings 31 and 77. This can be accomplished without drilling new wells, for there are abundant trees in the areas to support such an investigation.

4. The investigation reported here should be repeated to determine the importance of season on the tritium distributions measured on plant materials at the Laboratory, as with this study, the above improvements in analytical methodology should be instituted.

5. Expressing tritium activity results for extracted plant water in pCi/L may facilitate comparisons with reported tritium concentrations in other waters (rain, soil water, and groundwaters) at Berkeley Lab, which are customarily reported in pCi/L.

References

Kalisz, P. J., J. W. Stringer, J. A. Volpe, and D. T. Clark. Trees as Monitors of Tritium in Soil Water. Journal of Environmental Quality 17 no. 1, 1988.

Stewart, G. L., T. A. Wyerman, M. Sherman, and R. Schneider. Tritium in Pine Trees from Selected Locations in the United States, including Areas near Nuclear Facilities. U.S. Geological Survey Prof. Paper 800B (1972) B265, 1972.

Brown, R. M. Environmental Tritium in Trees. Atomic Energy of Canada Limited, Chalk River Nuclear Laboratories. IAEA-SM-232/44

Richard, W. H., and L. J. Kirby. Trees as Indicators of Subterranean Waterflow from a Retired Radioactive Waste Disposal Site. Health Physics 52: 201-206, 1987.

Site Environmental Report (1995), Lawrence Berkeley National Laboratory.

Maintenance Program for a Safe Sustainable Landscape, LBNL (Facilities Dept.).

Table 9-2. Unbound Tritium Activity in (pCi/L) in Plant Foliage *vs* Distance from the NTLF Stack in 1996

Distance (m) to NTLF stack	Transect WE		Transect NS		
	West	East	North	South	Average
50	17667	5219	8104	6875	9466
100	13842	1277	3556	303	4745
150	11587	1296	2773	1022	4170
200	4346	315	2761	673	2024
250	775	239	1723	503	810
300	571	323	1400	202	624

Nearest (~2m) tree to NTLF Stack = 77355 pCi/L

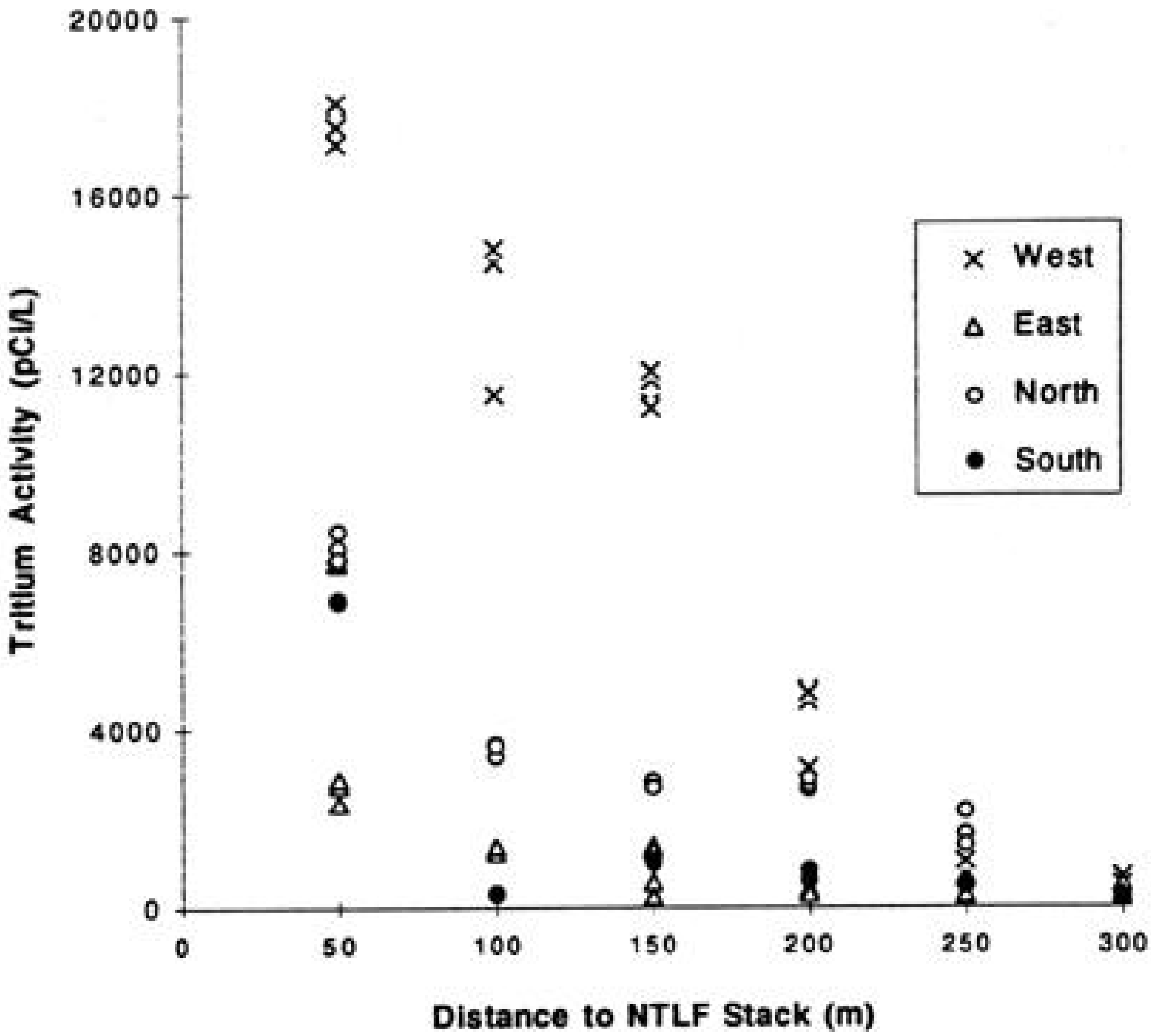
Table 9-3. Organically-bound Tritium Activity in (pCi/G) in Plant Foliage *vs* Distance from the NTLF Stack in 1996

Distance (m) to NTLF stack	Transect WE		Transect NS		
	West	East	North	South	Average
50	209	13	64	24	78
100	345	69	104	22	135
150	252	<9.26	71	<9.14	161
200	55	<9.00	61	<9.85	58
250	<7.33	<6.40	<6.24	<8.52	
300	<7.73	<8.82	29	16	22

Nearest (~2m) tree to NTLF Stack = 524 pCi/G

Figure 9-2.

Unbound Tritium in Vegetation vs Distance to NTLF Stack



Panoramic Hill Association

Post Office Box 5428
Berkeley, California 94705

Director Charles Shank
Lawrence Berkeley National Laboratory
1 Cyclotron Road
Berkeley, CA 94720

May 4, 2000

Dear Director Shank,

At the April 26, 2000, General Meeting of the Panoramic Hill Association, the majority present voted to request the following inventory data from the Lawrence Berkeley National Laboratory and the Department of Energy:

1. All shipping documents pertaining to shipments of tritium into NTLF inventory since September 1, 1996.
2. All shipping documents pertaining to tritiated product shipped out of NTLF since August 19 1997.
3. All shipping documents pertaining to shipments of recaptured/recycled tritium shipped out of NTLF since January 1, 1996. Receiving documents from the Lawrence Livermore National Laboratory (LLNL) should be included to indicate the actual amount of tritium that was received from NTLF by LLNL and logged into DOE's inventory database.
4. All documentatation pertaining to transfers of tritium waste from the NTLF to LBNL' s Hazardous Waste Handling Facility (HWHF) since January 1, 1996.
5. All shipping documents pertaining to tritium waste shipped out of LBNL's HWHF since 3/31/1997.

The members present also expressed the wish that the Task Force continue to meet until such time as the inventory data have been made available and distributed to all Task Force members.

As you know, the Panoramic Hill Association is one of only two neighborhood association participants in the Environmental Sampling Task Force. As you also know, our neighborhood is in Strawberry Canyon. Our stake in this process is the physical health of ourselves and our families. Because of the genetic effects of tritium exposure. also at stake is the physical health of future generations. We want peace of rnind. We want confidence in the process by which risks are estimated and conclusions reached. For these reasons, we request that you comply with the long-standing request for these records.

Sincerely,

Janice Thomas, President

Director Charles Shank
Lawrence Berkeley National Laboratory
1 Cyclotron Road
Berkeley, CA 94720

May 24, 2000

Dear Director Shank:

Thank you for the Nuclear Materials Management and Safeguard System (NMMSS) transaction data attached to the letter from David McGraw, dated 5/11/2000, in response to the Panoramic Hill Association's request for tritium shipping documents to verify tritium inventory at the Lawrence Berkeley National Laboratory's (LBNL) Tritium Labeling Facility.

The NMMSS data are not in a readily understandable form for community members currently participating at LBNL's Environmental Sampling Task Force, without a proper explanation for each of the codes used in the report. We respectfully ask you to provide clarification in the form of the original shipping documents pertaining to the following items from the NMMSS data.

We are identifying the requested items from the NMMSS data by their ACTDATE/LN# & WT.

ACTDATE/LN#	W1: (weight)	
19950514/1	0.47	
19950519/1	0.49	
19960201/1	1.00	
19970630/5	0.12	
19970630/1	0.22	
19980930/1	1.16	
19981028/1	0.69	
19990426/1	0.01	
4-6-00	0.25	(LLNL correction to 10/28/98 * recycling shipment)
4-7-00	0.32	(Waste shipment to Hanford)*

* The last two items were listed on the other attachment under heading 3. Inventory update to 4-28-2000 and provided to Bernd Franke of IFEU, the city of Berkeley's contractor.

In addition, please provide copies of shipping documents for all tritiated product shipments since 8/19/1997, which was the date of the last shipping document given to the community, as well as providing an updated "unofficial" readily understandable tritium inventory listing, such as the 8/13/1998 document provided to the Tritium Issues Work Group. It would he most appreciated if you forward all these documents to us prior to the June 1, 2000 Task Force Meeting.

Sincerely,

Eric Arens, President
Campus Parnassus
Neighhorhood Association
1501 Campus Drive
Berkeley, CA 94708

Jami Caseber, Director
Citizens Opposed to a
Polluted Environment
1908 10th Street
Berkeley, CA 94710

Gene Bernardi, Co-chair
Committee To Minimize
ToxicWaste
9 Arden Road
Berkeley, CA 94704

Berkeley Lab
Environment, Health & Safety Division

May I 1, 2000 DIR-00-108

Ms. Janice Thomas
Post Offic Box 5428
Berkeley, CA 94705

SUBJECT: Letter to Dr. Charles Shank, Lawrence Berkeley National Laboratory Director, Dated May 4, 2000

Dear Ms. Thomas,

I am responding to your letter requesting tritium inventory data from the Lawrence Berkeley National Laboratory and the Department of Energy. The Laboratory has responded to a tritium inventory information request from the City of Berkeley's consultant, Bernd Franke. The response is enclosed, including a report of tritium transactions at Berkeley Lab from 12/31/67 to 12131/99. The report is from the Department of Energy's Nuclear Materials Management and Safeguards System (NMMSS), an inventory and transaction reporting tool mandated for use within the DOE system. Although somewhat complicated (the NNMMSS manual DOE M 474.1-2 itself is 185 pages long), this tool contains the most comprehensive and up-to-date tritium inventory data.

Please be aware that the NMMSS inventory data does not have sufficient precision to estimate tritium emissions to the environment. The preferred method is by direct measurements of those emissions using stack sampling systems. Stack sampling is the method that EPA requires for assessing public health impacts under the Clean Air Act. LBNL monitoring systems provide complete and continuous measurements of tritium emissions from NTLF and HWHF stacks with a sensitivity and precision exceeding what would be possible using inventory data. Samples taken of the ambient air and of human urine validate stack measurements. Results of environmental monitoring emissions are entered into NMMSS as reportable transactions.

I appreciate your expression of concern and hope that you will recognize the Laboratory's efforts to respond. Please feel free to contact me at 486-5551 or Ron Pauer at 486-7614 for any additional discussion of the tritium inventory information.

Sincerely,

David McGraw
Division Director
Environment, Health and Safety Division

enclosure

Tritium Inventory, Mass Balance

Question: Can you provide me with a current inventory of tritium purchases, releases, shipments and disposals at LBNL? I have such data for Jan 1, 1969 to Aug 1, 1998 which was provided to the TIWG. Has there been an update and/or a change? I would like to receive the most current version of this, if possible in a spreadsheet format. I got the impression that the lab inventory at a given point is a calculated value (shipments received minus product shipments, releases, disposal, recycling, corrected for decay). Please correct me if I am wrong. 'Where are procedures documented to verify current inventories?

Answer:

1. Inventory procedures and documentation

The Nuclear Materials Management and Safeguards System (NMMSS) is the inventory and transaction reporting tool mandated for use by DOE contractors using tritium. NMMSS system procedures can be found in DOE M 474.1-2, Nuclear Materials Management and Safeguards System Reporting and Data Submission, which is available on the internet at http://www.explorer.doe.gov:1776/htmls/regs/doe/newserieslist.htrn1.

Because NMMSS is mandated for use within DOE, it has been maintained complete and up to date in lieu of the unofficial tritium inventory listing which was provided to TIWG. The unofficial inventory listing was prepared as a readily understandable reply to a broad request for information from TIWG; it was a simplified listing compared to the much more complicated material in NMMSS (the NMMSS manual DOE M 474.1-2 itself is 185 pages long). A copy of the NMMSS database listing of LBNL tritium transactions from 12-31-67 to 12-31-99 is being forwarded under separate cover.

Note that the NMMSS inventory is kept in units of grams, to a precision of 0.01 g (96 Ci), where the present conversion factor from grams to curies is 9619 curies per gram. In the past various other conversion factors have been used, namely 9680 Ci/g (historical), 9700 Ci/g (rounded value per DOT), and 10,000 Ci/g (nominal value). Since it is generally unknown exactly which conversion coefficient was used at different times in the past 30 years, this represents a source of uncertainty (~ 3%) in historical transaction data. The reporting threshold for NMMSS transactions is 0.005 g (48Ci); all NMMSS transactions are rounded to the nearest 0.01g for reporting purposes.

A recent analysis of LBNL tritium inventory and transaction data in NMMSS has shown that the precision of the current inventory figure is most limited by the uncertainties in the tritium content of past waste shipments, i.e. prior to 1996. (There is no disposal of this waste at LBNL.) When radioactive waste is generated it is assigned a nominal tritium content based on process knowledge and historical data. Since 1996, the nominal content values have been partially verified by sampling some or all of the containers. Recent experience has shown that the overall uncertainty in the tritium content of waste has been on the order +/- 25%. Prior to 1996 no QA verification of waste tritium content was required.

Due to these uncertainties, NMMSS inventory data do not have sufficient precision to support mass balance analyses of tritium emissions. To reiterate, the uncertainties in the tritium content of past waste shipments are larger than the amounts of tritium released in emissions. Therefore it would not be meaningful to attempt to use inventory data to validate release measurements. The preferred method of determining amounts of tritium released to the environment is by direct measurements of those emissions. LBNL monitoring systems provide complete and continuous measurements of tritium emissions from NTLF and HWHF stacks with a sensitivity and precision exceeding what would be possible using inventory data. Results of environmental monitoring of emissions are entered into NMMSS as reportable transactions.

While LBNL current estimates of tritium activity in the NTLF and the HWHF agree with the NMMSS balance within the limits of uncertainty, and meet current DOE requirements, improved precision would be desirable to enhance stakeholder confidence. To that end, LBNL is currently procuring a calorimetry system designed to enable accurate measurement of tritium activity on uranium storage and recycling beds. The calorimeter will also be evaluated for use in estimating the tritium content of waste containers, currently the greatest source of uncertainty in the inventory process. The calorimeter system was technically reviewed by the NTLF's Technical and Safety Advisory Committee on 4/13/2000.

2. Inventory update to 12-31-99

The NMMSS database listing provided separately covers transactions dated from 12-31-67 through 12-3199. Transactions listed since 8-1-98 are summarized below. The balance on 8-1-98 was 1.14 g (10,970 Ci) The balance on 12-31-99 was 1.47 g (14,140 Ci). (Note that tritium product shipments totaling 20 Ci for 1998 and 10 Ci for 1999 remain below the NMMSS transaction reporting threshold.)

Date	**Amount (g)**	**Transaction**	**Balance (g)**
8-1-98		Balance	1.14
9-30-98	1.16	Receipt from SRS	2.30
9-30-98	-0.02	Decay	2.28
10-28-98	-0.69	Recycling shipment to LLNL	1.59
12-31 -98	-0.03	Decay	1.56
3-31-99	-0.02	Decay	1.54
4-26-99	-0.01	Waste to INEEL	1.53
6-30-99	-0 02	Decay	1.51
9-30-99	-0.02	Decay	1.49
12-31-99	-0.02	Decay	1.47

3. Inventory update to 4-28-2000

The following NMMSS reportable tritium transactions have occurred since 12-31-99, and will be reflected in future NMMSS reports. After entry of these recent transactions, the tritium balance will be 1.36 g (13,080 Ci) as of April 28, 2000.

Date	**Amount (g)**	**Transaction**	**Balance (g)**
3-30-00	-0.02	Roll up entry for emissions: 1997 (41 Ci), 1998 (115 Ci), 1999 (30 Ci)	1.45
3-30-00	-0.02	Decay	1.43
4-6-00	0.25	LLNL correction to 10-28-98 recycling shipment	1.68
4-7-00	-0.32	Waste shipment to Hanford	1.36

4. Ongoing accountability

Internal tracking systems to ensure ongoing accountability of tritium inventory at LBNL's NTLF and HWHF are summarized in the diagram shown below.

This system provides that all LBNL receipts and shipmcnts of tritium (and other radioisotopcs used in other laboratories) are managed through the Radioactive Materials Transportation Office (RMTO), including waste shipments. Radioisotopes delivered to LBNL are screened against the ordering laboratory's Radiological Work Authorization to ensure that laboratory is authorized to receive the material, i.e. appropriate administrative and engineering controls, including environmental monitoring, are in place to handle the material safely. All receipt and shipping transactions reportable to NMMSS system are transmitted by the RMTO. Air emissions data from stack monitors are likewise reported to RMTO for reporting to NMMSS. (Tritium discharges to the sanitary sewer have also been, and continue to be, monitored but are too small in quantity to be reported in NMMSS.) Hence, any tritium entering or leaving the Berkeley Laboratory is tracked and accounted for by appropriate inventory procedures.